THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
2009

# TABLE OF CONTENTS

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 5-10, 2009

# LES of the Flow around an Oscillating Cylinder

**Andreas Feymark***
andreas.feymark@chalmers.se

**Niklas Alin*,°**

**Rickard Bensow***

**Christer Fureby*,°**

* Dept. of Shipping and Marine Technology, Chalmers University of Technology, SE-412 96, Göteborg, Sweden

° Defense Security Systems Technology, The Swedish Defense Research Agency – FOI, SE 147 25 Tumba, Stockholm, Sweden

## ABSTRACT

*Non-linear viscous flow around an oscillating cylinder attracts due to the complex phenomena created. The use of LES and DES enable us to predict not only the mean flow but also the transient nature of the flow. LES, [2-3], is based on the idea of separating scales, and splitting the flow into two regimes by which all scales larger than the characteristic grid spacing, Δ, are resolved using a space/time accurate algorithm and only the effects of the unresolved subgrid scales on the large resolved scales are modeled. Good agreement is achieved concerning the prediction of the peak frequencies in all cases, but with some discrepancy in the intensity distribution between the peaks.*

**Keywords:** LES, oscilating cylinder, experimental tests.

## REFERENCES

[1] **Bishop, R.E.D., Hassan, A.Y**., "*The Lift and Drag Forces on a Circular Cylinder in a Flowing Fluid*", Proc. Roy. Soc. (London) A 277, pp. 32, 1964.
[2] **King, R.,** "*A Review of Vortex Shedding Research and its Application*", Ocean Engineering, 4, pp. 141, 1977.
[3] **Fureby, C.,** "*Towards Large Eddy Simulation in Engineering*", Prog. Aerospace Science, 44, pp. 381, 2008.
[4] **Sagaut, P.,** "*Large Eddy Simulation for Incompressible Flows*", Springer Verlag, 2001.
[5] **Grinstein, F. F., Margolin, L. G., Rider, W. J. (Eds)**, "*Implicit Large Eddy Simulation Computing Turbulent Fluid Dynamics*", Cambridge University Press, 2007.
[6] **Nikitin, N.V., Nicoud, F., Wasistho, B., Squires, K.D., Spalart, P.R.,** "*An Approach to Wall Modeling in Large Eddy Simulation*", Phys. Fluids, 12, pp. 1629, 2000.
[7] **Wilcox, D.C.,** "*Turbulence Modeling for CFD*", DCW Industries, 1993.
[8] **Ongoren, A., Rockwell, D.,** "*Flow structure from an oscillating cylinder, part 2, Mode competition in the near wake*", Journal of Fluid Mechanics, Vol. 197, pp. 225-246, 1988.
[9] **Williamson, C. H. K., Roshko, A.,** "*Vortex formation in the wake of an oscillating cylinder.*", Journal of Fluids and Structures, Vol. 2, pp. 355-381, 1988.
[10] **Cetiner, O., Rockwell D**., "*Streamwise oscillations of a cylinder in a steady current.*", Part 1, Journal of Fluid Mechanics, Vol 427, pp. 1-28, 2001.
[11] **Cetiner, O., Rockwell, D**., "*Streamwise oscillations of a cylinder in a steady current.*", Part 2 Journal of Fluid Mechanics, Vol 427, pp. 1-28, 2001.
[12] **Cetiner, O.,** "*Flow Structure and Loading Due to an Oscillating Cylinder in a Steady Current.*", Ph.D dissertation, 1998
[13] **Liefvendahl, M., Lillberg, E.,** "*Computational Methods for Unsteady Fluid Force Predictions Using Moving Mesh Large Eddy Simulations*", AIAA 2005-4144, 2005.
[14] **Lu X–Y, Dalton, C.**, "Calculation *of the timing of vortex formation from an oscillating cylinder.*", Journal of Fluids and Structures, Vol. 10, pp. 527-541, 1996.
[15] **Saritas, M., Cetiner, O.**, "*Flow structure and loading due to an oscillating cylinder in steady current*", 7th International Symposium on Fluid Control, 2003.
[16] **Fureby, C., Bensow, R**., "*LES at Work: Quality Management in Practical LES*", Invited Review paper at QLES 2007. To appear in the Proceedings of the Conference, Springer Verlag, 2007.
[17] **Schumann, U.,** "*Subgrid Scale Model for Finite Difference Simulation of Turbulent Flows in Plane Channels and Annuli*", J. Comp. Phys., 18, pp. 376, 1975.
[18] **Fureby, C.,** "*On LES and DES of Wall Bounded Flows*", Ercoftac Bulletin No 72, Marsh Issue.
[19] **Weller, H.G., Tabor, G., Jasak, H., Fureby, C**., "*A Tensorial Approach to CFD using Object Oriented Techniques*", Comp. in Physics, 12, pp. 629, 1997. 2007.
[20] **Demirdzic, I., Peric, M.,** "*Space Conservation Law in Finite Volume Calculations of Fluid Flow*", International journal for numerical methods in fluids, Vol. 8, pp. 1037-1050, 1988.
[21] **Jasak, H., Tukovic, Z**., "*Automatic Mesh Motion for the Unstructured Finite Volume Method*", Submitted to Journal of Computational Physics, 2004.
[22] **Dröge, M**., "*Cartesian Grid Methods for Turbulent Flow Simulation in Complex Geometries*", Doctoral Dissertation, University of Groningen, 2007.
[23] **Lourenco, L., Shih, C.,** "*Characteristics of the plane turbulent near wake of a circular cylinder.A particle image velocimetry study*." Data taken from [23], 1993.
[24] **Tremblay, F.**, "*Direct and large-eddy simulation of flow around a circular cylinder at subcritical Reynolds number*", Doctoral dissertation, Technical University of Munich, 2001.
[25] **Ma, X., Karamons, G-S., Karniadakis, G.E.**, "*Dynamics and low-dimensionality of a turbulent near wake*", Journal of Fluid Mechanics, 410, pp. 29-65, 2000.

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 11-16, 2009

# 2D RANS Simulation on Overset Grids

**Jörg Brunswig**
Hamburg University of Tehchnology (TUHH), Germany Institute of Fluid Dynamics and Ship Theory (M-8)
E-mail: joerg,brunswig@tu-hamburg.de

**Manuel Manzkei**
Hamburg University of Tehchnology (TUHH), Germany Institute of Fluid Dynamics and Ship Theory (M-8)
E-mail: manuel.manzkei@tu-hamburg.de

**Thomas Rung**
Hamburg University of Tehchnology (TUHH),
Germany Institute of Fluid Dynamics and Ship Theory (M-8)
E-mail: thomas.rung@tu-hamburg.de

## ABSTRACT

*Rigid computational grids represent a strong limitation on the geometric complexity of CFD computations. The overlapping grids technique implemented in the in-house simulation tool FreSCo+ represent the best tradeo between flexibility and feasibility, in terms of programming and computational effort, based on arbitrary polyhedral cells or hanging nodes (structured or unstructured grids).*

**Keywords:** grid generation, overlapping grids, numerical simulation, RANS.

## REFERENCES

[1]. **Hadžić, H.,** *"Developmenet and Application of a Finite Volume Method for the Computation of Flows Around Moving Bodies on Unstructured, Overlapping Grids"*, PhD thesis, Hamburg University of Technology, 2005.

[2]. **Ferziger, J.H., Perić, M.,** *“Computational Fluid Dynamics”*, Springer, 2002.

[3]. **Fleischmann, P.,** *"Mesh Generation for Technology CAD in Three Dimensions"*, PhD thesis, Vienna University of Technology, 1999.

[4]. L**öhner, R.,** *“Applied Computational Fluid Dynamics Techniques”*, John Wiley Sons, Ltd, 2008.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 17-22, 2009

# Numerical Investigation of the Wing-Body Junction Flows

**Costel Ungureanu**
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture, Galati,
Domneasca Street, No. 47, 800008, Romania,
E-mail:costel.ungureanu@ugal.ro

**Adrian Lungu**
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture, Galati,
Domneasca Street, No. 47, 800008, Romania,
E-mail:adrian.lungu@ugal.ro

## ABSTRACT

*Steady high Reynolds numbers flowfield around a wing-body junction were numerically simulated by solving three-dimensional incompressible RANS equations with finite volume method. The flow is assumed to be fully turbulent so that the transition on the strut is not considered. Closure to the turbulence is attained through the use of the one equation Spalart-Allmaras model.*

**Keywords:** juncture flow, numerical simulation, RANSE, wing-body junction

## REFERENCES

[1]. **Dickinson, S.C**., *"Time dependent flow visualization in the separated region of an appendage-flat plate junction"*, Experiments in Fluids 6, pp 141-143, 1988.
[2]. **Ölçmen S., Simpson, L.,** *"Some features of a turbulent wing–body junction vortical flow"*, International Journal of Heat and Fluid Flow, No 27, pp 980-993, 2006.
[3]. **Kim, S.Y., Mori, K.,** *"A Study on Juncture Flows; Effects of the Inclination of Strut and the Curvature of Plate"*, Journal of Society of Naval Architects of Japan, pp 267-275, 1992.
[4]. **Kuwahara, K et al**., *"Direct Simulation of a Flow around an Airfoil"*, JSCFD Jones , D.A., 2000.
[5]. **Clarke, D.B.,** *"Simulation of a Wing- Body Junction Experiment using the Fluent Code"*, DSTO Platforms Sciences Laboratory, 2005.
[6]. **Song Fu et. al**., *"Simulation of wing-body junction flows with hybrid RANS/LES methods"*, International Journal of Heat and Fluid Flow, No 28, pp 1379-1390, 2007.
[7]. **Ungureanu, C., Lungu, A.**., *"Numerical Simulation of the Turbulent Flow around a Strut Mounted on a Plate"*, Numerical Analysis and Applied Mathematics, AIP Proceedings, Melville New York, Vol. 1168, pp. 689-692, 2009.
[8]. **Ölçmen S., Simpson, L.,** *"Wing-Body Junction with Separation"*, ERCOFTAC "Classic Collection" Database.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 23-28, 2009

# Numerical Study of a Submerged Two-Dimensional Hydrofoil Using Different Solvers

**Andrea Califano**
Department of Marine Technology - NTNU
Rolls-Royce University Technology Center '*Performance in a Seaway*'
*califano@ntnu.no*

## ABSTRACT

*The problem of a submerged hydrofoil has caught much attention after the experiments carried out by Duncan (1983). The present analysis focuses on the validation and verification of the solver in the case of a two dimensional hydrofoil close to the free surface. The open source code OpenFOAM (2009) has been used for the computations, and its results compared with the numerical simulation of Califano (2008), performed using Fluent (2006). All simulations are in good agreement with the experimental data, but the wave amplitude is underestimated.*

**Keywords:** submerged hydrofoil, numerical simulation, experimental validation

## REFERENCES

[1] **Califano, A.**, "*Influence of the near wall treatment on the flow features around a two-dimensional hydrofoil close to the free surface*", 11-th Numerical Towing Tank Symposium - NuTTS'08, 2008.
[2] **Califano, A., Steen, S.**, "*Analysis of different propeller ventilation mechanisms by means of rans simulations*", First International Symposium on Marine Propulsor - smp'09, 2009.
[3] **Cointe, R., Tulin, M. P., "***A theory of steady breakers*", Journal of Fluid Mechanics, 276(-1):1–20, 1994.
[4] **Duncan, J. H.**, "*Breaking and non-breaking wave resistance of a two-dimensional hydrofoil*", Journal of Fluid Mechanics, 126:507 – 520, 1983.
[5] **Faltinsen, O. M.**, "*Hydrodynamics of High-Speed Marine Vehicles"*, Cambridge University Press, 2005.
[6] **Faltinsen, O. M., Semenov, Y. A.**, "*The effect of gravity and cavitation on a hydrofoil near the free surface"*, Journal of Fluid Mechanics, 597(-1):371– 394, 2008.
[7] **Fluent**, *Fluent 6.3 User's Guide*, Fluent Inc. 2006.
[8] **Koushan, K.**, "*Dynamics of ventilated propeller blade loading on thrusters"*, World Maritime Technology Conference - WMTC'06, 2006.
[9] **Landrini, M., Lugni, C., Bertram, V**., "*Numerical simulation of the unsteady flow past a hydrofoil"*, Ship Technology Research, 46(1):14 – 30, 1999.
[10] **Menter, F.**, "*Two-equation eddy-viscosity turbulence models for engineering applications"*, AIAA Journal, 2(8):1598 – 1605, 1994.
[11] **Mori, K. H., Shin, M. S**., "*Sub-breaking wave: Its characteristics, appearing condition and numerical simulation"*, Proceedings 17th Symposium on Naval Hydrodynamics, The Hague, The Netherlands, 1988.
[12] **Muscari, R., Di Mascio, A.**, "*A model for the simulation of steady spilling breaking waves"*, Journal of Ship Research, 47(1):13–23, 2003.
[13] **Nishiyama, H.**, "*Air-drawing and ventilating flow characteristics of shallowly submerged hydrofoil sections*", American Society of Naval Engineers – Journal, 73(3):593 – 602, 1961.
[14] **OpenFOAM, "***Open FOAM User Guide*", 2009.
[15] **Rhee, S. H., Stern, F**., "*Rans model for spilling breaking waves.*", Journal of Fluids Engineering, Transactions of the ASME, 124(2):424 – 432, 2002.
[17] **Tzabiras, G.**, "*Numerical investigations of 2d, steady free surface flows*", International Journal for Numerical Methods in Fluids, 25(5):567 – 598, 1997.
[18] **Weissinger, J.**, "*Lift distribution of swept-back wings*", 1947.
[19] **Wilcox, D. C.**, "*Turbulence Modeling for CFD*", DCW Industries, Inc., 2nd edition, 2004.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 29-34, 2009

# Numerical Flow Simulation around an Appended Ship Hull

**Florin Pacuraru**
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture,
Galati, Domneasca Street, No. 47, 800008,
Romania,
E-mail: florin.pacuraru@ugal.ro

**Adrian Lungu**
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture,
Galati, Domneasca Street, No. 47, 800008,
Romania,
E-mail: adrian.lungu@ugal.ro

## ABSTRACT

*The paper proposes a numerical investigation based on RANS computation for solving the viscous flow around a fully appended tractor tug hull. Various simulations were carried out to compute the flow around different appendage configurations, from the bare hull case to fully appended hull, to study the influence of the each appendage on the ship wake and resistance. For practical reasons, the technique couples a body forces method and a RANS-based finite volume solver to account for the interactions between the hull and the appendages mounted on it: propellers, pods, safe guard, brackets and skeg. The chimera approach has been found the most versatile way for grid generation of hull and appendages.*

**Keywords:** turbulent flow, finite volume method, appendage.

## REFERENCES

[1] **Zhang, D.H., Broberg, L., Larsson, L., Dyne, G.**, *"A Method for Computing Stern Flows with an Operating Propeller"*, RINA Transactions, 134, 1992.
[2 ]**Zhou, L., Zhao, F.,** *"An integrated method for computing the internal and external viscous flow field around the ducted propulsor behind an axisymmetric body"*, Proceedings of the 20th ONR Symposium, pp. 1011–1020, 1994.
[3] **Steger, J.L.,** *"The Chimera Method of Flow Simulation, Workshop on Applied CFD"*, University of Tennessee Space Institute, 1991.
[4] **Steger, J.L., Dougherty, F.C., Benek, J.,** *"A Chimera Grid Scheme Advanced in Grid Generation"*, ASME FED, Vol. 5, pp. 59-69, 1983.
[5] **Wang, Z.,** *"A Fully Conservative Interface Algorithm for Overlapped Grids"*, J. Comput. Phys, 122, pp. 96-106, 1995.
[6] **Regnström, B., Broberg L., Larsson, L.,** *"Overlapping composite grids for ship stern flow calculations"*, MARNET-CFD First Workshop, Barcelona, 1999.
[7] *** *"ShipFlow User's Manual"*, FlowTech International, 2003.
[8] **Obreja, D., Popescu, G., Pacuraru, F.,** *"Resistance Tests Report. Tractor Tug"*, Research Project No. 344/2004, "Dunarea de Jos" University of Galati, 2004.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 35-40, 2009

# A Numerical Study of Breaking Bow Waves for Different Ship Hulls

**Andrea Colagrossi**
INSEAN,
The Italian Ship Model Basin, Rome,
Italy
E-mail: a.colagrossi@insean.it

**Salvatore Marrone**
INSEAN,
The Italian Ship Model Basin, Rome
University of Rome, SAPIENZA
Italy

**Matteo Antuono**
INSEAN,
The Italian Ship Model Basin, Rome,
Italy

**Marshall Peter Tulin**
Ocean Engineering Laboratory, UCSB

## ABSTRACT

*The present work 2D+t approach for wave breaking, the analysis is limited to fast slender ships with sharp stem. Also SPH and Mixed Eulerian-Lagrangian (MEL) method approaches are employed in this paper. During the first stages of the evolution, the hull section moves toward the free surface similarly to a water-entry phenomenon. Consequently, a violent water displacement occurs generating a water run-up along the ship bow. Such a motion is fed by the expansion of the ship cross section leading to a bow breaking wave. This phenomenon is highlighted in the first three panels of figure 3 where the breaking bow waves obtained through the BEM solver at different Froude numbers and for the three hulls under consideration are shown.*

**Keywords:** ship resistance, wave breaking, experimental tests.

## REFERENCES

[1] **Landrini, M., Colagrossi, A., Tulin, M.P.,** ***"Numerical Studies of Wave Breaking Compared to Experimental Observations",*** Proc. of 4th Numerical Towing Tank Symposium (Ed. V. Bertram), Hamburg, 2001.
[2] **Colagrossi, A., Antuono, M., Marrone, S.**, ***"A 2D+t SPH model with enhanced solid boundary treatment"***, Proc. of 4th International SPHERIC Workshop, Nantes, France, May 2009.
[3] **Maruo, H., Song, W.**, ***"Nonlinear Analysis of Bow Wave Breaking and Deck Wetness of a High-Speed Ship by the Parabolic Approximation"***, 20th Symposium on Naval Hydrodynamics, University of California, Santa Barbara, 1994.
[4] **Wu, M., Tulin, M.P., Fontaine, E.**, ***"On the Simulation of Amplified Bow Waves Induced by Motion in Head Seas"***, J. Ship Res., 2003.
[5] **Tulin, M.P., Wu, M.**, ***"Divergent bow waves"***, Proc. of the 21st ONR Symp. on Naval Hydrodynamics, Trondheim, Norway, National Academy Press, Wash. D.C., pp. 99–117, 1996.
[6] **Longuet-Higgins, M.S., Cokelet, E.D.**, ***"The deformation of steep surface waves on water. I. A numerical method of computation"***, Proc. of the Roy. Soc. Lond. A. 350, 1976.
[7] **Faltinsen, O.M.**, ***"Numerical solutions of transient nonlinear freeÂŋsurface motion outside or inside moving bodies"***, Proc. of the Second International Conference on Numerical Ship Hydrodynamics, University of California, Berkeley, 1977.
[8] **Landrini, M., Colagrossi, A., Greco, M., Tulin, M.P.**, ***"Gridless simulations of splashing processes and near-shore bore propagation"***, Journal of Fluid Mechanics, 591, 183–213 2007.
[9] **Colagrossi, A., Antuono, M., Le Touzé, D**., ***"Theoretical considerations on the free surface role in the SPH model"***, Phys. Rev. E., 79/5: 056701:1–13, 2009.
[10] **Monaghan, J.J.**, ***"Smoothed Particle Hydrodynamics"***, Reports on Progress in Physics, Institute of Physics Publishing, 68, 1703-1759, 2005.
[11] **Lugni, C., Colagrossi, A., Landrini, M. and Faltinsen, O.M.**, ***"Experimental and Numerical Study of Semi-displacement Mono-hull and Catamaran in calm water and incident waves"***, Proc. of 25th Symp.on Naval Hydrodynamics, St. John's, Canada, 2004.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 41-46, 2009

# Using Approximation Functions for Hydrodynamic Pressure on Rapid Ship Bottom

**Dumitru Dragomir**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street,
RO-800008 Romania
E-mail: dumitru.dragomir@ugal.ro

**Leonard Domnisoru**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street,
RO-800008 Romania
E-mail: leonard.domnisoru@ugal.ro

**Alexandru Ioan**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47Domneasca Street,
RO-800008 Romania
E-mail: ioan.alexandru@ugal.ro

## ABSTRACT

*Unlike common (slow) ships, rapid ships display a significantly different pressure loading on the bottom. Besides the hydrostatic pressure, the hydrodynamic pressure can reach high values and has to be taken into consideration for the structural FEM checking. Given the huge amount of data input operations, an automation of loading modelling is highly necessary, so that the authors successfully attempted to devise a procedure to create an approximation function for those hydrodynamic pressures resulted from a CFD program as point-pressure pairs of values, transforming them into a continuous function, to be added to the hydrostatic pressure. This way a more accurate FEM consideration of the hydrodynamic loadings can be achieved, to the benefit of ship safety.*

**Keywords:** hydrodynamic pressure, hydrostatic pressure, FEM, modelling, approximation function, ship safety.

## References

[1] **SRAC** , COSMOS/M, SOLID WORKS, 2007.
[2] **AeroHydro Inc.,** Multisurf, 2000.
[3] **CompassIS**, GID-TDYN, 2007.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 47-50, 2009

# Benchmarking-Purpose Simulations of the Free-Surface Flow around the KCS Hull

**Viorel Gabriel Maria**
"Dunarea de Jos" University of Galati,
Department of Ship Hydrodynamics,
47 Domneasca Street, Galati 800008, Romania, E-mail: viorel.maria@ugal.ro

**Adrian Lungu**
"Dunarea de Jos" University of Galati,
Department of Ship Hydrodynamics,
47 Domneasca Street, Galati 800008, Romania, E-mail: adrian.lungu@ugal.ro

## ABSTRACT

*The main focus of the present study is on the of computational fluid dynamics (CFD) evaluation of the overall ship performances as a tool for hull form design. The numerical results of the numerical approach are presented and discussed for the KCS containership designed by the Korean Research Institute for Ships and Ocean Engineering (KRISO). Comparisons of the numerical solution with available experimental fluid dynamics (EFD) data are given. Similar steady flow simulations around the KCS model were also performed at KRISO and used for benchmarking purposes. The data include wave elevation along the hull surface, global wave pattern, resistance and mean velocity components in boundary layer and wake transverse cuts. Comparisons are performed hereinafter and the results prove satisfactory resemblance for the current investigation.*

**Keywords:** KCS ship hull, numerical simulation, free-surface flow, turbulence.

## REFERENCES

[1] **Kim, J.W., Van, S.H., Kim, D.H.,** *"Measurements of flows around modern commercial ship models"*, Experiments in Fluids, pp. 567-578, Springer, 2001.
[2] **Tahara, Y., Wilson, R.V., Carrica P.M., Stern, F.,** "*RANS simulation of a container ship using a single-phase level-set method with overset grids and the prognosis for extension to a self-propulsion simulator*", pp. 209-228, Springer, 2006.
[3] **Larsson, L., Stern, F., Bertram, V.,** "*Benchmarking of Computational Fluid Dynamics for Ship Flows: The Gothenburg 2000 Workshop*", Journal of Ship Research, Vol.47, No.1, pp. 63-81, 2003.
[4] **Larsson, L., Stern, F., Bertram**, **V**., "*Summary conclusions and recommendations of the Gothenburg 2000 workshop*." Chalmers University of Technology, Gothenburg, Sweden, 2000.
[5] **Tahara, Y., Ando, J.,** "*Comparison of CFD and EFD for KCS container ship in without/with propeller conditions*", Chalmers University of Technology, Gothenburg, Sweden, 2000.
[6] ***SHIPFLOW 4.2*** "*Users Manual*", 2008.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 51-54, 2009

# Simulating a Cavitating Propeller in Wake Flow

**Rickard E. Bensow**
Dept. of Shipping and Marine Technology
Chalmers University of Technology, Sweden,
rickard.bensow@chalmers.se

## ABSTRACT

*An improved understanding of cavitation dynamics, using both experimental and simulation results, is a crucial component to prevent or reduce cavitation effects, such as material damage or noise, and thereby, to increase propeller performance. In the present study, Large Eddy Simulation (LES) techniques are used to simulate the cavitating flow on a propeller in the case of inhomogeneous inflow conditions. The interface between liquid and vapor is captured using a Volume of Fluid (VoF) approach and a mass transfer model is used for the vaporization and condensation processes.*

**Keywords:** Large Eddy Simulation, the cavitating flow, Volume of Fluid.

## REFERENCES

[1] **Stella, A., Guj G., Di Felice F.,** "Propeller wake flowfield analysis by means of LDV phase sampling technique," Exp. in Fluids, 28, 2000.
[2] **Di Florio, D., Di Felice, F., Romano, G.P, Elefante, M.,** "*Propeller wake structure at different advance coefficients by means of PIV,*" PSFVIP-3, Maui, Hawaii, USA, 2001.
[3] **Di Felice, F., Felli, M., Giordano, G., Soave, M.,** "*Pressure and velocity correlation in the wake of a propeller,*" Propeller Shafting, Virginia Beach, Norfolk, USA, 2003.
[4] **Pereira, F., Salvatore, F., Di Felice, F.,** "*Measurement and modeling of propeller cavitation in uniform inflow,*" J. Fluids Engrng., **126**:671–679, 2004.
[5] **Pereira, F., Salvatore, F., Di Felice, F., Soave, M.,** "*Experimental Investigation of a Cavitating Propeller in Non-Uniform Inflow,*" 25th ONR Symposium on Naval Hydrodynamics, St John's, Canada, 2004.
[6] **Bensow, R.E., Liefvendahl, M.,** "*Implicit and Explicit Subgrid Modeling in LES Applied to a Marine Propeller,*" AIAA-2008-4144, 2008.
[7] **Streckwall, H., Salvatore, F.,** "*Results of the Wageningen 2007 Workshop on Propeller Open Water Calculations Including Cavitation*", RINA CFD 2008, Southhampton, UK, 2008.
[8] **Salvatore, F., Streckwall, H., Terwisga, T.V.,** "*Propeller Cavitation Modelling by CFD - Results from the VIRTUE 2008 Rome Workshop,*" 1st Int. Symposium on Marine Propulsors, Trondheim, Norway, 2009.
[9] **Bensow, R.E., Huuva, T., Bark, G., Liefvendahl, M**., "*Large Eddy Simulation of Cavitating Propeller Flows,*" 27th Int. Symposium on hip Hydrodynamics, Korea, 2008.
[10] **Kunz, R. F., Boger, D. A., Stinebring, D.R., Chyczewski, T. S., Lindau, J. W., Gibeling, H. J., Venkateswaran, S., Govindan, T. R.**, "*A preconditioned Navier-Stokes method for two-phase flows with application to cavitation prediction*", Computers and Fluids 29(8), 2000.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 55-60, 2009

# Numerical Flow Investigation around a Ship Model with Propeller and Rudder

**Oana Marcu**
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture, Galati,
Domneasca Street, No. 47, 800008, Romania
E-mail: oana.marcu@ugal.ro

**Adrian Lungu**
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture, Galati,
Domneasca Street, No. 47, 800008, Romania
E-mail: adrian.lungu@ugal.ro

## ABSTRACT

*A viscous flow investigation of a KVLCC2 model with propeller and rudder is described in the present work. A special attention is paid to the effect of propeller and rudder on the stern flow characteristics. The Reynolds-Averaged Navier-Stokes equations (RANS hereafter) accompanied by the EASM turbulence model are the governing equations to solve for accomplishing the task. The hydrodynamic behavior of the bare hull, the propeller and the rudder is studied and discussed by taking into consideration the mutual interactions.*

**Keywords:** KVLCC2, numerical simulation, actuator disk.

## REFERENCES

[1] **Kim, J.W., Van, S.H., Kim, D.H.,** *"Measurements of flows around modern commercial ship models"*, Experiments in Fluids, pp. 567-578, Springer, 2001.

[2] **Van, S.H., Kim, J.W., Yoon, H.S., Lee, Y.Y., Park, I.R.,** *"Flow measurement around a model ship with propeller and rudder"*, pp. 533-544, Springer-Verlag, 2006.

[3] **Ahmed, Y., Guedes Soares, C.,** *"Simulation of free surface flow around a VLCC hull using viscous and potential flow methods"*, Ocean Engineering, No.36, pp. 691-696, Elsevier Ltd. 2009.

[4] **Phillips, A.B., Turnock, S.R., Furlong**, **M**., "*Evaluation of manoeuvring coefficients of a self-propelled ship using a blade element momentum propeller model coupled to a Reynolds averaged Navier Stokes flow solver*", Ocean Engineering, No.36, pp. 1217-1225, Elsevier Ltd. 2009.

[5] ***SHIPFLOW 4.2*** *"Users Manual"*, 2008.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 61-66, 2009

# Numerical Assessment of a BEM-based Approach for the Analysis of Ducted Propulsors

**Danilo Calcagni**
INSEAN
Via di Vallerano 139
Rome (Italy),
E-mail: d.calcagni@insean.it

**Luca Greco**
INSEAN
Via di Vallerano 139
Rome (Italy)

**Francesco Salvatore**
INSEAN
Via di Vallerano 139
Rome (Italy)

## ABSTRACT

*The present work proposes a Boundary Element Method -based formulation, valid for inviscid flows around three-dimensional bodies in arbitrary motion, to address hydrodynamic analysis of ducted propellers. For both test cases considered experimental data related to thrust, torque and efficiency are available for ducted configuration (together with propeller and duct separate contribution to thrust), whereas for the latter case data for the isolated propeller are also given. Crucial issues arisen by the present analysis are the duct computational grid generation, the determination of the propeller wake shape and viscous phenomena modeling. In particular, the inclusion of a trailing-wake alignment model for the isolated propeller has proven to be effective in the enhancement of numerical predictions.*

**Keywords:** ducted propulsors, wake, thrust, torque.

## REFERENCES

[1] **Baltazar, J., Falcão de Campos, J.A.C.**, *"On the Modelling of the Flow in Ducted Propellers with a Panel Method"*, First International Symposium on Marine Propulsors, SMP09, Trondheim (Norway), June 2009.
[2] **Greco, L., Colombo, C., Salvatore, F., Felli, M.**, *"An Unsteady Inviscid-Flow Model to Study Podded Propulsors Hydrodynamics,"* Second International Conference on Technological Advances in Podded Propulsion, Brest (France), 2006.
[3]**Greco, L., Salvatore, F., Di Felice, F.**, *"Validation of a Quasi-potential Flow Model for the Analysis of Marine Propellers Wake"*, Twenty-fifth ONR Symposium on Naval Hydrodynamics, St. John's, Newfoundland, Canada, 2004.
[4] **Kerwin, J.E., Kinnas, S.A., Lee, J.-T., Shih, W.-Z.**, *"A surface panel method for the hydrodynamic analysis of ducted propellers"*, Transaction SNAME, vol. 95, 1987.
[5] **Harvald, S. A.**, *"Resistance and Propulsion of Ships"*, Wiley Interscience Pubblication, New York, USA, 1992.
[6] **Hughes, M.J.**, *"Implementation of a Special Procedure for Modeling the Tip Clearance Flow in a Panel Method for Ducted Propellers"*, Propellers/Shafting '97 Symposium, Virginia Beach (USA), 1997.
[7] **Kuiper, G.**, *"The Wageningen Propeller Series"*, Marin Pubblication 92-001, 1992.
[8] **Morino, L, Chen, L.T., Suciu, E.**, *"Steady and Oscillatory Subsonic and Supersonic Aerodynamics around Complex Configurations"*, AIAA Journal, Vol. 13, pp. 368-374, 1975.
[9] **Morino, L.**, *"Boundary Integral Equations in Aerodynamics"*, Applied Mechanics Reviews, Vol. 46, No. 8, pp. 445-466, 1993.
[10] **Salvatore, F., Testa, C., Ianniello, S., Pereira, F.**, *"Theoretical Modelling of Unsteady Cavitation and Induced Noise"*, Proceedings of CAV 2006 Symposium, Wageningen, The Netherlands, 2006.
[11] **Salvatore, F., Calcagni, D., Greco, L.**, *"Ducted propeller performance analysis using a boundary element model"*, INSEAN Technical Report / 2006-083, 2006.
[12] **Sanchez-Caja, A., Pylkkanen J.V., Sipila, T.P.**, *"Simulation of the Incompressible Viscous Flow around Ducted Propellers with Rudders Using a RANSE Solver"*, 27th Symposium on Naval Hydrodynamics, Seoul (Korea), 2008.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 67-74, 2009

# Hydrodynamic Design and Analysis for a Controllable Pitch Propeller

**Mihaela Amoraritei**
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture,
Galati, 47 Domneasca Street, 800008, Romania,
E-mail: mihaela.amoraritei@ugal.ro

## ABSTRACT

*The paper deals with the hydrodynamic design and analysis of a controllable pitch propeller for a general cargo vessel. The main advantages and disadvantages of CPP are presented and the design criteria are reviewed. A wake adapted propeller has been computer-designed, based on the lifting line theory with correction factors on the lifting surface theory. Computations of open water performances for different pitch angles have been performed using a commercial CFD code. An analytical tool has been developed to perform power/speed prognosis, finding the optimum combination of pitch/propeller revolution rate for different operating conditions.*

**Keywords:** controllable pitch propeller, hydrodynamic performances

## REFERENCES

[1] **Carlton, J.S.,** "*Marine Propellers and Propulsion*", Elsevier, pp. 20-22, 2007.
[2] **Ceanga, V., Mocanu, I.C., Teodorescu, C.,** "*Dinamica sistemelor de propulsie*", Ed. Didactica si Pedagogica, Bucuresti, pp. 85-99, 2003 (in Romanian).
[3] **Ghose, J.P., Gokarn, R.P.,** "Basic Ship Propulsion", Allied Publishers Pvt. Limited, pp. 365-369, 2004.
[4] **Watson, D.G.M.,** "*Practical Ship Design*", Elsevier, pp. 209-210, 2002.
[5] **van Beek, T.,** "*Improved Controllable Pitch Propeller Concept Offers Better Vessel Performance*", The Ship Power Supplier, Wartsila, pp. 28, 2-2004.
[6] **Lewis, E.,** "*Principles of Naval Architecture*", SMAME, pp. 230-231, 1988.
[7] **Kuiper, Ir.G.,** "*Cavitation*", 34th Wegemt Course, 2000.
[8] **Mac Grow, H.,** "*Encyclopedia of Science and Technology*", pp. 473, 1997.
[9] **Holtrop, J.,** "*The Design of Propellers*", 34th Wegemt Course, 2000.
[10] **van Beek, T.,** "*Technology guidelines for efficient design and operation of ship propulsors*", The Ship Power Supplier, Wartsila, pp. 14-18, 1-2004.
[11] **van Gunsteren, Ir.L.A.,** "*Hydrodynamics of Controllable Pitch Propellers*", Delft Postgraduate Course III Ship Propulsion, 1969.
[12] **Harrington, R.,** "*Marine Engineering*", pp.385-386, 1992.
[13] ***** MAN B&W,** "CP Propeller Equipment", Technical Paper, 2007.
[14] ***** MAN B&W,** "*Basic Principles of Ship Propulsion*", Technical Paper, 2006.
[14] ***, "*Study of Greenhouse Gas Emissions from Ships*", Final Report to the International Maritime Organisation, pp. 92, 2000.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 75-80, 2009

# Simulation of Lifetime Operating Conditions as Input Parameters for CFD Calculations and Design Evaluation

**Lars Greitsch**
Mecklenburger Metallguss GmbH
Teterower Str. 43/51
17192 Waren (Müritz)
Germany,
E-mail: greitsch@mmgprop.de

**Georg Eljardt**
Technische Universitat Hamburg – Harburg,
Schwarzenbergstraße 95
D-21073 Hamburg,
Germany,
E-mail: eljardt@tu-harburg.de

## ABSTRACT

*The newly developed approach described in this paper illustrates a procedure on how to gain the information needed for providing a prognosis on various design- and operation-relevant issues. Deploying the Monte Carlo Method (Sobol, 1984), the implemented algorithm features the ability to simulate the operation profile of a vessel according to a specific trade, taking into account the cargo the routing and the mostly anticipated weather conditions. This paper showed a new approach to benchmark different ship designs, keeping a clear focus on the operation. It has been proved that it is possible to simulate a complete lifecycle of a projected or existing vessel, using fore- and hindcasted operation data (ship-specific and environmental). The simulation results, regarding the power demand, are available in rather short computation time. The use of an entire manoeuvring simulation leads to a complete database of operational data.*

**Keywords:** Monte Carlo Simulation, resistance, rudder cavitation.

## REFERENCES

[1] **Eljardt, G.,** *"Development of a Fuel Oil Consumption Monitoring System"*, Diploma Thesis TUHH, Hamburg, 2006.
[2] **Eljardt, G., Greitsch, L., Mazza, G.,** *"Operation-based ship design and evaluation"*, International Maritime Design Conference, Trondheim, 2009.
[3] **Faltinsen, O. M.,** *"Sea Loads on Ships and Offshore Structures"*, Cambridge; New York: Cambridge University Press, 1990.
[4] **Greitsch, L.,** *"Prognosis of Rudder Cavitation Risk in Ship Operation"*, Numerical Towing Tank Symposium, Brest, 2008.
[5] **Greitsch, L., Eljardt, G.,** *"Operating Conditions Aligned Ship Design and Evaluation"*, 1st Symposium on Marine Propulsors, Trondheim, 2009.
[6] **Haack, T.,** *„Simulation des Manoevrierverhaltens von Schiffen unter besonderer Beruecksichtigung der Antriebsanlage"*, Dissertation, Schriftenreihe Schiffbau, Hamburg, 2006.
[7] **Haack, T., Krueger, S.,** *"Propulsion plant models for nautical manoeuvre simulations"*, Proceedings of the 3rd International Conference on Computer Applications and Information Technology in the Maritime Industries, Madrid, 2004.
[8] **Kendall, M.G.,** *"Rank Correlation Methods"*, London: Griffin, 1970.
[9] **Kruger, S.,** *"Manövriersimulation auf der Basis von Großausführungsmessungen"*, JSTG Vol. 92, Berlin: Springer Verlag, 1998.
[10] **Sobol, I. M.,** *"The Monte Carlo Method"*, Moscow: Mir Publishers, 1984.
[11] **Soding, H.,** *"Global Seaway Statistics"*, Inst. f. Schiffbau der Universität Hamburg – Bericht Nr. 610, 2001.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 81-86, 2009

# Correlation of Bow and Stern Slamming Occurrence with Whipping Excitation for a Cruise Vessel

**Daniele Dessi**
INSEAN,
The Italian Ship Model Basin, Rome,
Italy
E-mail: d.dessi@insean.it

**Michele De Luca**
INSEAN,
The Italian Ship Model Basin, Rome,
Italy

## ABSTRACT

*The present work bow and stern slamming impacts determined experimentally at the Italian ship model basin in head and following wave condition. The analysis of a seakeeping test campaign with a segmented model relative to a cruise ship has been presented. The most interesting phenomenon that was observed is indeed the stern slamming, mainly present in following sea with slow or no forward speed at all. Slamming on the afterbody due to following waves excites strongly the structure, confirming the reports relative to onboard observations.*

**Keywords:** bow and stern slamming, seakeeping, experimental tests.

## REFERENCES

[1] **Dessi, D., Mariani, R.,** *"Analysis and prediction of slamming-induced loads of a high-speed monohull in regular waves"*, Journal of Ship Research, Vol. 52, pp. 71-88, 2008.
[2] **Ochi, M.K., Motter, L.E.,** *"Prediction of slamming characteristics and hull responses for ship design,"* Trans. SNAME, Vol. 81, pp. 144-176, 1973.
[3] **Ferro, G., Mansour, A.E.,** *"Probabilistic analysis of the combined slamming and wave induced responses,"* Journal of Ship Research, Vol. 29, pp. 170-188,1985.
[4] **Dessi, D., De Luca, M., Mariani, R., Carapellotti, D.,** *"Analysis of the ship response to stern slamming loads,"* PRADS 2007, Houston, TX, pp.193-210, 2007.

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 87-96, 2009

# Non-linear Hydroelastic Dynamic Response in Irregular Head Waves, for a 7500 tdw Chemical Tanker Ship

**Leonard Domnisoru**
University “Dunarea de Jos” of Galati
Faculty of Naval Architecture
Galati, Domneasca Street, No. 47,
RO-800008 Romania
E-mail: leonard.domnisoru@ugal.ro

**Dumitru Dragomir**
University “Dunarea de Jos” of Galati
Faculty of Naval Architecture
Galati, Domneasca Street, No. 47,
RO-800008 Romania
E-mail: dumitru.dragomir@ugal.ro

**Alexandru Ioan**
University “Dunarea de Jos” of Galati
Faculty of Naval Architecture
Galati, Domneasca Street, No. 47,
RO-800008 Romania
E-mail: ioan.alexandru@ugal.ro

**Daniela Domnisoru**
The Naval Transport High-School of Galati
Department of Physics
Galati, Portului Street, No. 56,
RO-800211 Romania
E-mail: ddomnis@yahoo.com

## ABSTRACT

*The main topics of this study are the analyses of the steady state and transitory hydroelastic dynamic response of a chemical tanker ship, induced by irregular head waves, model Longuet-Higgins. There are considered two loading cases: full cargo and ballast. The analyses have been carried on with the eigen program DYN. The numerical model includes linear-modal frequency domain procedures and also non-linear time domain direct integration procedures for the motion equations solution. The numerical results pointed out the occurrence of the slamming phenomenon at both ship extremities, so that in the ship girder are recorded very high whipping transitory vibrations. For the numerical analyses is used the chemical tanker 7500 tdw model provided by the ICEPRONAV Galati, in the frame of the CEEX EU-SSS Project. The numerical results pointed out that the non-linear analyses could reveal the extreme wave loads in the ship hull structure.*

**Keywords:** hydroelasticity theory, seakeeping, non-linear ship dynamic response.

## REFERENCES

[1] **Bertram, V.**, “*Practical ship hydrodynamics*”, Butterworth Heinemann, Oxford, 2000.
[2] **Bishop, R.E.D., Price, W.G.**, “*Hydroelasticity of ships”*, Cambridge University Press, 1979.
[3] **Belik, O., Bishop, R.E.D., Price, W.G.**, “*A simulation of ships response due to slamming in irregular head waves”*, The Royal Institution of Naval Architects, London, No.125, pp. 237-253, 1983.
[4] **Domnisoru, L., Domnisoru, D.**, “*The unified analysis of springing and whipping phenomena”*, The Royal Institution of Naval Architects, London, No. 140(A), pp.19-36, 1998.
[5] **Domnisoru, L., Domnisoru, D.**, “*Experimental analysis of springing and whipping phenomena”*, International Shipbuilding Progress, Delft, No. 47(450), pp.129-140, 2000.
[6] **Domnisoru, L.**, “*Ship dynamics. Oscillations and vibrations of ship hull”*, The Technical Publishing House, Bucharest, 2001.
[7] **Domnisoru, L., Ioan A.**, “*Non-linear hydroelastic response analysis in head waves, for a large bulk carrier ship hull”*, Advancements in Marine Structures, Taylor & Francis, London, pp.147-158, 2007.
[8] **Domnisoru, L., Domnisoru, D.**, “*The Numerical Analysis of Transitory Dynamic Response, based on the non-linear Hydroelasticity Theory, for a Barge Test Ship”*, Romanian Journal of Physics, Section Applied Physics – Mechanics, Vol.53, No.1-2, pp.129-136, 2008.
[9] **Domnisoru, L., Lungu, A., Dumitru, D., Ioan, A.**, “*Ship structural and hydrodynamic analyses”*, University Press, Galati, 2008.
[10] **Fonseca, N., Guedes Soares, C.**, “*Comparison between experimental and numerical results of the non-linear vertical ship motions and loads on a containership in regular waves*”, International Shipbuilding Progress, Delft, No. 52(1), pp.57-89, 2005.
[11] **GL.**, “*Germanischer Lloyd’s Rules”*, Hamburg, 2007.
[12] **Hirdaris, S.E., Price, W.G, Temarel, P.**, “*Two and three-dimensional hydroelastic modelling of a bulk carrier in regular waves”*, Marine Structures, No. 16, pp. 627-658, 2003.
[13] **Hirdaris, S.E., Chunhua, G.**, “*Review and introduction to hydroelasticity of ships”*, Lloyd’s Register, London, 2005.
[14] **Park, J.H., Temarel, P.**, “*The influence of nonlinearities on wave-induced motions and loads predicted by two-dimensional hydroelasticity analysis”*, The 10th International Symposium on Practical Design of Ships and Other Floating Structures, PRADS, Houston, Vol. 1, pp. 27-34, 2007.
[15] **Perunovic, J.V., Jensen, J.J.**, “*Non-linear springing excitation due to a bi-directional wave field”*, Marine Structures, No.18, pp. 332-358, 2005.
[16] **Perunovic, J.V.**, “*Springing response due to bi-directional wave excitation”*, PhD Thesis, Technical University of Denmark, Department of Mechanical Engineering, 2005.
[17] **Tao, Z, Incecik, A.**, “*Non-linear ship motion and global bending moment predictions in regular head seas”*, International Shipbuilding Progress, Delft, No. 47(452), pp.353-378, 2000.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 97-102, 2009

# Estimation of Hydrodynamic Wave-Induced Loads for a Bulk Carrier Vessel

**Sandita Pacuraru**

University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture,
Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: sorina.pacuraru@ugal.ro

## ABSTRACT

*The paper presents computed wave-induced hydrodynamic loads using Frank formulation of source method for the case of a 70000 tdw bulk carrier vessel. The computer code is a ship motion and sea load computer program, based on the theory of Salvesen, Tuck and Faltinsen. It predicts the motion and dynamic loads for a ship in six-degrees-of freedom advancing at constant speed with arbitrary heading in regular waves. The code computes the amplitudes and phases for the surge, sway, heave, roll, pitch, and yaw motion and the vertical and horizontal shear forces, bending moments and moments of torsion. In addition to the motions and loads the computer program predicts, at selected points on the submerged portion of the hull, the amplitude and the phase angle of the hydrodynamic pressure due to the motions and the incoming wave.*

**Keywords:** 2D Source Method, wave-induced vertical shear force and vertical bending moment.

## REFERENCES

[1] **Ming-Chung Fang, Chih-Chung Fang, Chun-Hsien Wu**, *"Prediction of design wave loads of the ocean structure by equivalent irregular wave approach"*, Ocean Engineering 34 (2007) 1422–1430, 2006.
[2] **Phelps, B.P.,** *"Determination of Wave Loads for Ship Structural Analysis"*, DSTO Aeronautical and Maritime Research Laboratory, 1997.
[3] **Pedersen, P.T., Jensen, J. J.,** *"Estimation of hull girder vertical bending moments including non-linear and flexibility effects using closed form expressions"*, Proc. IMechE Vol. 223 Part M: J. Engineering for the Maritime Environment, 2009.
[4] **Faltinsen, O.M.,** *"Sea Loads on Ships and Offshore Structures"*, Cambridge Univ. Press, 1993.
[5] **Salvesen, N., Frank, W., Faltinsen, O.,** *" Ship-Motion and Sea-Load computer program"* NSRDC Report, 1972.
[6] **Domnişoru, L.,** *"Dinamica navei în mare reală"*, Editura Evrika, Brăila, 1997.
[7] **Huang, W., Moan, T.**, "Combination of global still-water and wave load effects for reliability-baseddesign of floating production, storage and offloading (FPSO) vessels", Applied Ocean Research 27 127–141, 2005.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 103-108, 2009

# Experimental and Numerical Analysis of the Roll Decay Motion for a Patrol Boat

**Riccardo Broglia**
INSEAN,
Rome/Italy

**Benjamin Bouscasse**
INSEAN,
Rome/Italy

**Andrea Di Mascio**
INSEAN,
Rome/Italy

**Claudio Lugni**
INSEAN,
Rome/Italy
c.lugni@insean.it

## ABSTRACT

*In this paper an experimental and numerical analysis of the roll decay for a patrol boat is carried out. Numerical simulations have been carried out for three different Froude number. The mathematical model employed for the simulations of the flow field is described by the Reynolds Averaged Navier-Stokes equations. The effect of the rotating propeller has been considered in the model experiments. A strong interaction between the vorticity shed from the fin and the bilge keel has been also shown. Numerical simulations appear to slightly underpredict the damping, with an undamped roll decay at the lowest speed.*

**Keywords:** roll decay motion, numerical analysis, model experiments.

## REFERENCES

[1] **Atsavapranee, P., Engle, A., Grant, D., Carneal, J., Beirne, T., Etebari, A., Percival, A., Rosario, J., Lugni, C.,** "*Full-Scale Investigation of Viscous Roll Damping with Particle Image Velocimetry"*, Proc. of 27th Symposium on Naval Hydrodynamics, Seoul, Korea, 2008.

[2] **Di Mascio, A., Broglia, R., Muscari, R.,** "*On the Application of the One Phase Level Set Method for Naval Hydrodynamic Flows*", Computer and Fluids, 36(5):868-886, 2007.

[3] **Di Mascio, A., Broglia, R.,** "*Prediction of Hydrodynamic Coefficients of Ship Hulls by High-Order Godunov-Type Methods*". J. Marine Sci.Tech., 2008.

[4] **Favini, B., Broglia, R., Di Mascio, A**., "*Multigrid Acceleration of Second Order ENO Schemes from Low Subsonic to High Supersonic Flows*", Int. J. Num.Meth. Fluids, 23:589-606, 1996.

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 109-114, 2009

# Steady and Unsteady Flow Simulation for DTMB Combatant 5415

**Mirel Nechita**
University “Dunarea de Jos” of Galati,
Faculty of Naval Architecture,
Galati, Domneasca Street, No. 47, 800008,
Romania,
E-mail: mirel.nechita@ugal.ro

**Adrian Lungu**
University “Dunarea de Jos” of Galati,
Faculty of Naval Architecture,
Galati, Domneasca Street, No. 47, 800008,
Romania,
E-mail: adrian.lungu@ugal.ro

## ABSTRACT

*The paper presents the numerical analysis of steady and unsteady flow for Combatant 5415 in order to estimate the ship behavior (including ship motions and the unsteady forces acting on the ship hull) in sea conditions. Numerical simulations were necessary to provide useful information about the pressure and velocity fields on the wetted hull surface, the ship behavior in order to make the modification of the bodylines more efficient. For the unsteady problem is proposed a seakeeping computation method taking into account the influence of the steady wave field for estimating the hydrodynamic forces acting on the ship hull and the response functions. The proposed computation methods predicts the steady wave field in good accuracy, this being one important condition for the consequent unsteady wave field computations. The steady problem is solved so that the fully nonlinear free-surface condition is satisfied and evaluating consequently the influence terms of the steady wave field on the unsteady wave field. The unsteady boundary value problem is liniarized assuming the small amplitude of the incident waves and ship motions. The boundary conditions for the unsteady problem are satisfied on the exact steady free-surface and wetted surface of the body. The numerical results are carefully compared with experiments. Finally, it is emphasized that the present simulation is confirmed to be effective to solve the steady and unsteady flow for the ship.*

**Keywords:** Rankine Panel Method, steady waves, unsteady waves, ship motions.

## References

[1] **Jensen, G., Mi, Z-X., Soeding, H**., *“Rankine Source Methods for Numerical Solutions of the Steady Wave Resistance Problems”*, 16th Symposium on Naval Hydrodynamics, Berkeley, pp. 575-582, 1986.
[2] **Nechita, M., Iwashita, H., Iwasa, H., Hidaka, Y., Ohara, H.,** *“Influence of the Fully Nonlinear Steady Wave Field on the Unsteady Wave Field of a Blunt Ship Advancing in Waves”*, Transaction of the West-Japan Society of Naval Architects, No. 101, pp. 37-48, 2000.
[3] **Timman, R., Newman, J. N.**, *“The Coupled Damping Coefficients of a Symmetric Ship”*, Journal of Ship Research, 5/4, pp. 1-6, 1962.
[4] **Newman, J. N.,** *“The Theory of Ship Motions”,* Advances in Applied Mechanics, 18, pp. 221-283, 1978.
[5] **Bertram, V**., *“Ship Motions by a Rankine source Method”*, Ship Technology Research, 37, pp. 143-152, 1990.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 115-118, 2009

# Modification of the Rudder Geometry for Energy Efficiency Improvement on Ships

**Alejandro Caldas Collazo**
Vicus Desarrollos Technológgicos, S.L.,
Vigo, Spain
E-mail: a.caldas@vicusdt.com

**Adrián Sarasquete Fernández**
Vicus Desarrollos Technológgicos, S.L.,
Vigo, Spain
E-mail: a.sarasquete@vicusdt.com

## ABSTRACT

*Fuel consumption is one of the major costs faced by any fleet, specifically determinant for fishing fleets, and any decrease in the consumption will be welcome by shipowners. The main goal is improving the energy recovery through the rudder so can increase the energy efficiency of the ship with a quite low investment since the shipowner only has to substitute the rudder blade. Complex interaction phenomena occurs among propeller, rudder and hull, affecting `propulsive efficiency indifferent ways and are numerically investigated with a coupled BEM-RANSE technique.*

**Keywords:** ship resistance, numerical simulation,

## REFERENCES

[1]. **Bertram, V.,** *"Practical Ship hydrodynamics"*, Butterwoth-Heinemann, 2002.
[2]. **Carlton, J.,** *"Marine propellers and Propulsion"*, $2^{nd}$ Edition, Butterwoth-Heinemann, 2007.
[3]. **Li, Da-Quing,** *"Investigatioon on Propeller-rudder interaction by numerical methods"*, PhD thesis, Chalmers University of Technology.
[4]. **Ferziger, J.H., Perić, M.,** "*Computational Methods for Fluid Dynamics*", Springer, 2000.
[5]. **Molland, A.F., Turnock, S.R.,** "*Marine Rudders and Control Surfaces*", Butterwoth-Heinemann, 2007.
[6]. **Söding, H.,** "*Limits of potential theory in rudder flow predictions*", Twenty-Second Symposium on Naval Hydrodynamics, Washington, D.C., 1998.
[7]. **Stierman, E.J.,** "*The influence of the rudder on the propulsive performance of ships Part I & II* ", Interntional Shipbuilding Progress, 36, $N^o$ 407, pp303-334, 1989 and $N^o$ 408, pp. 405-435, 1989.
[8]. **Streckwall, H.,** "*Rudder Cavitation. Numerical Analysys and Shape Optimization*", STG CFD in ship Design, Hamburg, 2007.
[9]. **Tetsui, Hoshino, et al.,** "*Development of high performance stator fin by using advanced panel method*", Mitsubishi Heavy Industries Technical Review, Vol. 41, $N^o$ 6, 2004.
[10]. **Vorhoelter, H., Krueger, S.,** "*Optimization of appendages using RANS-CFD Methods*", Numerical Towing Tank Symposium, Hamburg, 2007.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 119-126, 2009

# Investigation of Hydrodynamic Performance of a Small Passenger Ship

**Dan Obreja**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street, 800008
Romania
E-mail: dan.obreja@ugal.ro

## ABSTRACT

*The assurance of the ship's hydrodynamic safety constitutes an important concern in ship research and design activities. In this paper, the theoretical investigation of resistance, propulsion, manoeuvrability and seakeeping performance of a small passenger ship was considered. The theoretical investigation was performed on the basis of Initial Design module of "Aveva" code. The critical situations were determined, in order to avoid possible major accidents.*

**Keywords:** small passenger ship, resistance, propulsion, manoeuvrability, seakeeping.

## References

[1] **Aveva** code, "*Initial design Module*", 2008.
[2] **Kuiper, G.,** "*Resistance and Propulsion of the Ship*", Technical University Delft, 1991.
[3] **Interim Standards for Ship Manoeuvrability**, "*IMO Resolution A.751(18)*", 1993.
[4] **Bertram, V.,** "*Practical Ship Hydrodynamics*", Butterworth-Heinemann, Oxford, 2000.
[5] **Molland, A., Turnock, S.,** "*Marine Rudders and Control Surfaces*", Butterworth-Heinemann, Elsevier, 2007.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 127-132, 2009

# The Vibration Analysis of an Offshore Barge, Based on 3D-FEM Model Approach

**Ciprian Mihai Coreschi**
ICE ICEPRONAV Galati
Department of Ship Structural Design and Analysis
Galati, Portului Street, No. 19A,
RO-800025 Romania
E-mail: ciprian.coreschi@icepronav.ro

**Iulia Mirciu**
ICE ICEPRONAV Galati
Department of Ship Structural Design and Analysis
Galati, Portului Street, No. 19A,
RO-800025 Romania
E-mail: iulia.mirciu@icepronav.ro

**Virginica Enache**
University "Dunarea de Jos" of Galati
Faculty of Naval Architecture
Galati, Domneasca Street, No. 47,
RO-800008 Romania
E-mail: lesorins@hotmail.com

**Leonard Domnisoru**
University "Dunarea de Jos" of Galati
Faculty of Naval Architecture
Galati, Domneasca Street, No. 47,
RO-800008 Romania
E-mail: leonard.domnisoru@ugal.ro

## ABSTRACT

*In this paper is presented the ship structure free and forced vibrations analysis for an offshore barge with length 86.01 m. The numerical analysis is carried on 3D-FEM full-extended barge model, including the hull and superstructure elements, developed at ICEPRONAV Galati. The structural model includes the eigen masses at the ballast load case, the hydrodynamic added mass and the elasticity equivalent path of the surrounding water environment. The slamming pressure acting on the barge fore peak zone induces the forced vibration dynamic response, for a sea state Beaufort level 4-5, based on a direct time domain integration procedure. The numerical results are pointing out that some deflection, velocity and acceleration values in the living quarter of superstructure are above the onboard comfort values.*

**Keywords:** finite element analysis, free and forced vibrations, slamming pressure.

## REFERENCES

[1] **ABS.**, *"Guidance notes on ship vibrations"*, American Bureau of Shipping, Houston TX, 2006.
[2] **ABS.**, *"Rules for building and classing steel barges"*, American Bureau of Shipping, Houston TX, 2009.
[3] **Bertram, V.**, *"Practical ship hydrodynamics"*, Butterworth Heinemann, Oxford, 2000.
[4] **Bishop, R.E.D., Price, W.G.**, *"Hydroelasticity of ships"*, Cambridge University Press, 1979.
[5] **Domnisoru, L.**, *"Ship dynamics. Oscillations and vibrations of ship hull"*, The Technical Publishing House, Bucharest, 2001.
[6] **Domnisoru, L., Popovici, O., Gavan, E.**, *"The ship structure analysis based on the finite element method"*, The Didactic and Pedagogic Publishing House, Bucharest, 2005.
[7] **Domnisoru, L.**, *"Local and global ship vibrations"*, University Press, Galati, 2007.
[8] **Domnisoru, L., Lungu, A., Dumitru, D., Ioan, A.**, *"Ship structural and hydrodynamic analyses"*, University Press, Galati, 2008.
[9] **FEMAP**, *"FEMAP-Nastran NX User's Guide"*, Siemens PLM Software, 2007.
[10] **Frieze, P.A., Shenoi, R.A.** (editor), *"Proceedings of the 16-th International Ship and Offshore Structures Congress – ISSC"*, University of Southampton, 2006.
[11] **GL.**, *"Ship vibrations"*, GL-Technology, Hamburg, 2001.
[12] **GL.**, *"Germanischer Lloyd's Rules"*, Hamburg, 2008.
[13] **Hughes, O.F.**, *"Ship structural design. A rationally-based, computer-aided optimisation approach"*, The Society of Naval Architects and Marine Engineering, New Jersey, 1988.
[14] **ISO 6954**, *"Mechanical vibrations. Methods for the evaluation of the onboard merchant ship vibrations SR ISO 6954"*, Romanian Institute of Standardization, Bucharest, 1996.
[15] **Xing J.T.** (editor), *"Vibration Analysis and Comfort"*, Report FP6-Marstruct, 2005
[16] **Zienkiewicz O.C., Taylor R.L.**, *"The finite element method. Solid and fluid mechanics. Dynamics and non-linearity"*, McGraw-Hill Book Company, New York, 1988.

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 133-136, 2009

# FEM Analysis of a Conveyor Discharge System

**Octavian Dumitriu**
Ship Design Group Galati,
Galati, 53Dogariei Street,
800225, Romania,
E-mail: dumi@shipdesigngroup.eu

**Bogdan Lupu**
Ship Design Group Galati,
Galati, 53Dogariei Street,
800225, Romania,
E-mail: boo_a21@yahoo.com

## ABSTRACT

*The paper deals with a complex structural analysis of a conveyor system which is to be mounted on a hopper dredger. These analyses have been performed using FEM (Finite Element Method) to ensure that proper scantlings have been made and to check the effect of different combined loads. The purpose of the calculation is to verify that the stress values are within allowable stress limits, the deflections is acceptable and to establish hydraulic cylinder forces and stroke. An important task was to adjust the models so that to simulate the weight distribution and to input the particulars of hydraulic system into the model – i.e equal forces into cylinders. Three situations have been tested: extraction from resting position, intermediate and working position of the conveyors. For all the three situations the results obtained have been used to calculate the strength of all the components of the system: conveyor, shore arm, joints, pedestal, and foundation, resting supports.*

**Keywords**: Conveyor, dredger, strength, FEM.

### REFERENCES

[1] **Germanischer Lloyd**, “*Regulation for the construction and survey of lifting appliances*”.
[2] **Project 182-689**, “*Discharge system*”, SDG Galati.
[3] **COSMOS-V2.9 FEM Software.**

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 137-144, 2009

# Study of Tension Variation for the Shock Solicitation of GRP Panels

**Costel Iulian Mocanu**
"Dunarea de Jos" University of Galați
Faculty of Naval Architecture
Galați, 47 Domneasca Street, 800008
Romania
E-mail: costel.mocanu@ugal.ro

**Ovidiu Niculeț**
Dunarea de Jos" University of Galați
Facuty of Naval Architecture
Galați, 47 Domneasca Street,800008
Romania
E-mail: ovidiu_niculet@yahoo.com

**Bianca Cristea**
„Dunarea de Jos" University of Galați
Facuty of Naval Architecture
Galați, 47 Domneasca Street,800008
Romania
E-mail: bianca.cristea_ro@yahoo.com

**Coman Adrian**
„Dunarea de Jos" University of Galați
Facuty of Naval Architecture
Galați, 47 Domneasca Street,800008
Romania
E-mail: adrian_coman@yamil.com

## ABSTRACT

*Experimental determination of the tensions and deformation states generated on a flat or curved panel, made of GRP (glass reinforced polyester), at the impact with a steel sphere and the comparison of the measurement results with the ones obtained from numerical modelling are presented in this paper.*

**Keywords:** tension and deformation states, numerical and experimental results

## REFERENCES

[1] **Tong, L., Mouritz, A.P., Bannister, M.K.,** *3D Fiber Reinforced Polymer Composites"*, Elsevier Science Ltd, London, 2002.
[2] **Dragomir, D., Lungu,** A., **Domnisoru**, L., *"Complements the design in naval architecture"*, Didactic and Pedagogical Publishing, Bucharest, 2007.
[3] **Abrate, S.,** *"Impact on composite structures"*, Cambridge University Press, Cambridge, UK, 1998.
[4] **Mocanu, C.I.,** *"Strength of materials"*, Zigotto Publisher, Galati, 2007.
[5] **Mocanu, F., Bejan, L., Bitca**, C., *"Electrical resistive strain gauges applied to composite materials"*, Tehnopress Publisher, Iasi, 2004.
[7] **Domnisoru, L.,** *"Finite element method in shipbuilding"*, Engineering Publisher, Bucharest, 2001.
[8] **Rades, M.,** *"Methods for identification of dynamic mechanical systems"*, Engineering Publisher, Bucharest, 1992.

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 145-150, 2009

# Calculation of the Platform Structure Response to Earthquake Loads by Use of Linear Methods

**Daniel A. Pitulice**
“Dunarea de Jos” University of Galati,
Faculty of Naval Architecture,
Galati, 47 Domneasca Street, 800008, Romania,
E-mail: daniel.pitulice@ugal.ro

## ABSTRACT

*The present paper discusses the two linear methods of calculating the dynamic response of a fixed offshore platform to the action of an earthquake: a) time domain analysis; b) response spectrum analysis. The methods' theoretical bases are briefly presented, the two-dimensional model beam equivalent to the lumped masses of a marine platform and the dynamic displacements are numerically calculated, using the two methods, for a platform whose dynamic characteristics ([M], [K], [C]) are known. For the numerical analysis, the accelerogram of the San Fernando earthquake (1971) has been used. The analysis of the results leads to important conclusions, among which one according to which the response spectrum analysis does not provide the largest dynamic displacements and hence, it is not comprehensive enough.*

**Keywords:** earthquake, offshore platforms, response spectrum, time domain analysis.

## REFERENCES

[1] **Barltrop, N.D.P., Adams A.J.,** *"Dynamics of Fixed Marine Structures-Third edition"*, Butterworth – Heinemann, The Marine Technology Directorate Ltd., ISBN 0-7506-1046-8, 1991.
[2] * * * **American Petroleum Institute**, *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms,* Washington D.C., 1992
[3] **Godeau, A.J., Deleuil G.E.,** *“Dynamic Response and Fatigue Analysis of Fixed Offshore Structures”*, OTC 2260, Dallas Texas 1985.
[4] **Ifrim, M.,** *“Dinamica structurilor si inginerie seismica”*, Editura Didactica si Pedagogica, Bucuresti, 1985.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 151-156, 2009

# The Analysis of Ship Piping Systems Behaviour under Design Static Loads

**Alexandru Ioan**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street,
RO-800008 Romania
E-mail: ioan.alexandru@ugal.ro

**Leonard Domnisoru**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street,
RO-800008 Romania
E-mail: leonard.domnisoru@ugal.ro

**Dumitru Dragomir**
"Dunarea de Jos" University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street,
RO-800008 Romania
E-mail: dumitru.dragomir@ugal.ro

## ABSTRACT

*The analysis of stress distribution and flexibility for piping systems within contract design is mandatory in ensuring the ship's safety. The objective is to make sure that the maximum stresses are within the admissible range. This paper includes a model of air conditioning system mounted on a 41000 tdw ship tank, under prescribed static loads. The numerical analysis is based on the FEM method, with the CAESAR II program developed by COADE Engineering Software.*

**Keywords:** ship, piping system, stress analysis, flexibility, finite element method.

## REFERENCES

[1] **Don, F.,** "*Process Piping in Accordance with ASME Design, Construction and Mechanical Integrity*", Becht Engineering Company Workshop, Singapore, 2006.
[2] **CESAR II,** *"User's Guide"*, COAD Engineering Software 2007.
[3] **Germanisher Lloyd,** "*Rules for Classification and Construction of Ships,* Edition 2008.
[4] **Harrington R.L.,** "*Marine Engineering*", The Society of Naval Architects and Marine Engineering , USA, 1992.
[5] **Hinton E., Owen D.R.J.,** "*An Introduction to Finite Element Computations,* Pineridge Press Limited Swansea, UK, 1991.

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
PAGES 157-162, 2009

# Operational Reinforcement of the Towing Tank of “Dunarea de Jos” University of Galati

**Dan Obreja**
“Dunarea de Jos” University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street, 800008
Romania
E-mail: dan.obreja@ugal.ro

**Liviu Crudu**
“Dunarea de Jos” University of Galati
Faculty of Naval Architecture
Galati, 47 Domneasca Street, 800008
Romania
E-mail: liviu.crudu@ugal.ro

## ABSTRACT

*The research strategies regarding the innovative solutions in transport and the shipbuilding area require the development of the infrastructure in the specialized centers of ship hydrodynamics.*

*The experimental research infrastructure can be used for both the investigation of the hydrodynamic phenomena related to the flow around the ship, and the validation of the theoretical solutions. The model experimental tests represent an important instrument to decide the optimum ship design solution.*

*This paper deals with the new experimental equipments for resistance and propulsion model tests, purchased in the Towing Tank of “Dunarea de Jos” University of Galati are presented. The operational reinforcement was performed on the basis of the “PN II Capacities” national program, financed by the National Authority of Scientific Research (ANCS) in 2008.*

*Also, it presents the results of the resistance tests for the ITTC model, performed in the Towing Tank. The experimental results were compared with the data in the references, in order to determine an overall accuracy factor of the experimental model tests with the new technical facilities.*

**Keywords:** towing tank, resistance and propulsion equipments, experimental tests.

## References

[1] **Bertram, V.,** “*Practical Ship Hydrodynamics*”, Butterworth-Heinemann, Oxford, 2000.
[2] **Kuiper, G.,** “*Resistance and Propulsion of the Ship*”, Technical University Delft, 1991.